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ART. 3. REMARKS ON THE BEHAVIOR OF THE SQUIRREL  
TREEFROG, *HYLA SQUIRELLA*

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INTRODUCTION

Several years ago we became interested in the day-by-day activities of the local treefrogs and began keeping detailed notes on individuals observed during a continuing study of our back-yard fauna. Although much of this information has been published elsewhere (Goin and Goin, 1953; Goin, 1955) we have a residue of data on the non-breeding behavior of these frogs which we believe should be made available. The present paper deals with the habits and habitat of the Squirrel Treefrog, *Hyla squirella* Sonnini and Latreille.

The observations on which this paper is based were made in our back yard near Gainesville, Alachua County, Florida. The yard is a plot nearly rectangular in shape and approximately a third of an acre in extent, bordering on a typical North Florida mesic hammock. The most conspicuous and abundant trees are water oaks (*Quercus nigra*), but in addition there are black gums (*Nyssa sylvatica biflora*), sweetgums (*Liquidambar styraciflua*), hickories (*Carya* sp.), blue beeches (*Carpinus caroliniana*), several live oaks (*Quercus virginiana*), one small holly (*Ilex* sp.), a magnolia sapling (*Magnolia grandiflora*), and a large loblolly pine (*Pinus taeda*). The undergrowth in the yard has been cleared out but the leaf mold has been left undisturbed. Bordering the yard on three sides, however, is a dense thicket of seedling oaks, palmettos (*Sabal minor*) and shrubs and vines.

Observations in previous years on *Hyla squirella* had indicated that these frogs are present in considerable numbers in the yard during the fall, winter and spring months. Further, we had observed that they are nocturnal, stirring with the approach of darkness and settling down just after daylight. They show a strong tendency to return time after time to the same spot to rest during the day. We also noted that when the temperature drops below a certain level the frogs do not stir from their hiding places at night. It was in order to determine, if possible, the temperature at which activity ceases that we initiated an intensive study of the movements of these frogs in the fall of 1953. Late in August we set six stakes about four feet high across the eastern end of the lot. On top of each stake we inverted an empty tin can. This row of stakes with their cans was about fifty feet east of the house, parallel to and just at the edge of the woods bordering the yard. From October 22, 1953, until May 31, 1954, these cans were examined morning and evening for the presence of Hylas, as were the undergrowth bordering the yard and various other habitats, both natural and edificarian, in which we knew treefrogs were apt to occur.

## FALL RETURN

In Florida *Hyla squirella* breeds in the spring and summer, utilizing temporary ponds and flooded ditches as well as more permanent bodies of water. Not all of the frogs leave the area around our house at this time, for we hear the rain call throughout the summer months. This rain call should not be confused with the call given in the breeding choruses; in warm, humid weather it is uttered sporadically by resting individuals at any time during the day. Apparently the frogs that remain in the yard during the summer move high up in the tops of the oak trees for we almost never see them.

The summer of 1953 was one of the wettest ever recorded for northern Florida. The yard was flooded much of the time during late August and early September and although we observed no breeding activity, we did record treefrogs more frequently than normal for this time of year. Usually the reappearance of adult frogs in the hammock occurs quite abruptly toward the end of September.

In the fall, young *squirella* begin to invade the hammock in increasing numbers. We never saw more than one immature a day from the time the cans were put up until October 30 when we saw three. On October 31 we recorded 10. The young frogs seem to move into the hammock in waves. For the next 13 days we saw an average of four a day, then on November 14 we counted 15. There was apparently another wave on November 21, when we recorded 10, and another on November 24 when 17 were seen. This was the greatest number observed on any one day during the course of the study. On December 8, we recorded 16. Thereafter the fluctuations in number from day to day seemed more to reflect variations in temperature than to indicate fresh invasion.

## NUMBERS IN YARD

Since the preceding summer had been an unusually favorable one for breeding, the number of young *squirella* in the yard during the course of the study probably represents a high point in the population cycle for the area. It is difficult to form an accurate estimate of the actual number of frogs resident in the yard. It seems probable that not all of those which were noted when one of the "waves" moved in, found suitable niches and remained in the yard for the winter. The average number of young seen per day for each month was as follows: October (last week), 2.38; November, 5.97; December, 7.65; January, 4.81; February, 3.40; March, 3.29; April, 2.23; May, 2.43.

This decrease from midwinter to late spring was not due simply to the growth of the individual frogs to a size at which they were no longer recorded as immatures. Even in April and May the young of the previous summer are recognizable as not full grown. Although we made no measurements, our observations would tend to agree with those of Wright (1932, p. 322-323) that the one year olds are smaller than the two year old (and older?) ones. He lists 13 mm. as transformation size, 19-23 mm. as one year old and 26 mm. + for two year olds.

The decline in number of young recorded in the spring was undoubtedly due in part to mortality. We observed no actual instances of predation, but on one occasion a Rough Green Snake (*Opheodrys aestivus*) was found on two consecutive days coiled on the branches of a young water oak in the thicket just back of can no. 3. Several times Yellow Rat Snakes (*Elaphe obsoleta quadrivittata*), which we have previously reported (Goin; 1955, p. 101) preying on Hylas, were found in the vicinity. At 9:15 on the evening of February 4, a small Yellow Rat Snake was seen on a bar of the rack for the fuel oil tank against the back of the house. The temperature was then 59°. Two adult *H. squirella* and one *H. cinerea* had been on the bar during the day. Now one *squirella* remained on a leg of the rack below the *Elaphe*. At 11:00 P.M. the snake was still there and the frog jumped to the ground. The next morning, at 9:00 o'clock with the temperature at 46°, the *Elaphe* was coiled on the bar, a *squirella* was sleeping on a brace bar about an inch below the snake, and an *Anolis*, which had not been present the night before, was resting about 6 inches farther along on the same bar as the snake. At 10:30 the temperature had warmed up to 56° and the snake was beginning to stir a little. By 11:45 it was crawling slowly along the bar. The *Anolis* and *squirella* were still quiescent. Half an hour later, the snake was where the lizard had been, the lizard was gone, and the frog still slept on the brace bar below. The next time the rack was inspected the snake had left.

Adult *squirella* were much less numerous than were the young. We never saw more than three on any one day. The total number of records for each month were as follows: October (last week only), 7; November, 22; December, 10; January, 28; February, 44; March, 26; April, 0; May, 10. Many of these records represent the same frog seen day after day.

#### DEPARTURE IN SPRING

Carr (1940, p. 61) records breeding choruses of *squirella* in Florida from April 2 to August 20. No adult *squirella* were observed in the yard during April. The 10 records listed for May represent what was probably a single individual (possibly two). In marked contrast, the young were nearly as numerous in April (61 records) and May (66 records) as they were in March (78 records), and were still present when the study was terminated in June. This suggests that yearling *squirella* do not leave the winter habitat to move to the breeding ponds with the adults. During the humid rainy season in the summer they move higher up into the oak trees where they escape observation. Probably it is these yearlings that are responsible for the rain calls heard in the non-breeding habitats in the summer months.

#### SELECTION OF HABITAT—YOUNG

Table 1 gives the sites in the study area selected by immature *squirella* for daytime resting places from October 22, 1953 to May 31, 1954. Of the edificarian situations, the "rack" is the metal stand for the fuel oil tank which is located against the back of the house. The "pipe" is an iron pipe an inch in diameter, with one end angled upward to a height of

TABLE 1. SUMMARY OF DIURNAL NICHES SELECTED BY IMMATURE *HYLA SQUIRELLA* DURING THE NON-BREEDING SEASON

EDIFICARIAN	(4 WEEKS)												TOTAL	
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY						
CAN 1	9	20	36	29	17	3	3	3	3					120
CAN 2		8	12	6									1	27
CAN 3	1	6	22	4		8	1							42
CAN 4														0
CAN 5		25	47	18									1	91
CAN 6		1	44	25		9	30	41						150
RACK		3	9		9	5								26
PIPE			4	22	26	12	6	19						89
OTHER		1	2	1									1	5
TOTAL EDIFICARIAN	10	64	176	105	52	37	40	66						550
NATURAL														
OAKS	5	36	11											52
HOLLY	1	12	15	42	42	34	10							156
MAGNOLIA		7	5		4	7	8							31
PALMETTOES	2	46	28	1	1		3							81
OTHERS	1	14	3											18
TOTAL NATURAL	9	115	62	43	47	41	21	0						338
TOTAL	19	179	238	148	99	78	61	66						888



about 15 inches, lying on the ground behind can no. 3. Under natural situations, the records for the oaks and palmettos represent a number of stations in the edge of the thicket surrounding the yard. The holly, on the other hand, is a single small tree, standing in a rather isolated position in the yard about five feet west of can no. 2. The magnolia is an isolated sapling about five feet tall. A number of these records represent a single frog returning day after day to the same resting place. On the other hand, not all the records from one niche represent a single frog; for example, at least four frogs are known to have been involved in the records for cans no. 1 and no. 6.

It is apparent that there is a shift during the winter in the niches chosen by young *squirella*. When they first move into the yard, they do not select diurnal resting places that will serve throughout the winter. They rather seem to occupy the first available site they find and are much less apt to return to it the next morning. Apparently neither the young oaks nor the palmettos provide niches sufficiently sheltered to be utilized throughout the winter. All of the 52 records for young *squirella* on oaks and all but four of the 81 records on palmettos were made during October, November and December. Only the holly, and to a lesser extent the magnolia, were utilized consistently until late spring when some of the leaves begin to drop from these broad-leaved evergreens. The suitability of the holly as a winter niche is, we believe, a reflection of the structure of the leaves. They are leathery and tend to curl over at the edges. A resting *squirella* clings to the under side of one of these leaves, frequently choosing one that is lying on top of another leaf so that the frog can find better protection on the holly than on oak or palmetto leaves.

Edificarian situations were preferred to the majority of natural ones as permanent niches. During November, when the young frogs were just moving into the yard, 115 were found in natural situations and 64 in edificarian ones. In December there was a marked reversal with 62 frogs found in natural situations and 176 in edificarian. During February and March both types of habitats were utilized in approximately equal numbers, largely because of the availability of the holly. During May only edificarian sites were occupied.

One noticeable phenomenon was the failure of the frogs to utilize can no. 4 although they were observed in the other cans a total of 423 times. We suspected at first that there might be something about the can itself that repelled the frogs. On December 11 the can was exchanged for a fresh one and the old can placed on the outside kitchen window sill. The next morning a *squirella* was resting on the can on the sill. We suspect now that the absence of frogs in no. 4 was due to its position in the middle of the row. There was simply a much greater probability that a frog, as it moved along the edge of the wood, would reach a can at the end of the line and stop than that it would continue until it came to no. 4.

## SELECTION OF HABITAT—ADULTS

Table 2 shows the niches selected by adult *squirella* as diurnal resting places. In contrast to the young, adult *squirella* are much more inclined to select edificarian situations as soon as they arrive in the yard. Of 147 records, only five are from natural situations, four from the holly in October and November and one from a palmetto in November. In further contrast to the young, however, the adults did not utilize the cans to any extent (four records during October and November). The most favored site was the metal rack for the fuel oil tank. We recorded adult *squirella* from this rack 94 times from October through March. The other 44 records were all from situations around or close to the windows of the house—a jar on the kitchen window sill, a crack between the screen and window frame, the back porch, etc., so that all but nine of the records for adults were of frogs on or about the house. Probably this preference of the adults for niches close to the house is correlated with availability of food supply. The lighted windows attract insects in the evenings and the insects in turn attract the frogs. When these frogs seek daytime resting places, they simply go to the first sheltered niches they find. In marked contrast, only 31 of the 888 observations on immatures were made on or about the house. This suggests that there may be a difference in diet between the adults and young. Perhaps the latter feed more on ground-dwelling forms such as ants rather than on the flying insects which are attracted to the lighted windows.

## REACTIONS TO TEMPERATURE

Under appropriate weather conditions, *squirella* leaves its place of diurnal abode about dark and returns again about dawn the following morning. It was in order to determine the effect of temperature on these nightly wanderings that we began to make a check for the presence of *Hylas* after dark as well as in the mornings, recording whether or not the frog had stirred from its niche, and noting the temperature at the time the observation was made. We also recorded the low temperature for the diel period and the temperature at which the niches were inspected the following morning. The temperature readings were taken from a Taylor maximum-minimum thermometer fastened about five feet from the ground on an oak tree in the middle of the yard.

A total of 974 observations is summarized by means of the bar diagrams in Fig. 1. The discrepancy between this figure and the totals in the habitat tables results from the fact that occasionally a frog was disturbed when the niches were inspected in the morning or for some other reason left during the day. In each of these diagrams the vertical line represents the mean, the horizontal line represents the range, and the bar represents one standard deviation on each side of the mean to indicate dispersion. It can be seen that, even though there is overlap, there is a pronounced tendency for the frogs to remain in on cold nights and to forage on warm nights. It can further be seen that the young and adults react in essentially the same manner.

TABLE 2. SUMMARY OF DIURNAL NICHES SELECTED BY ADULT *HYLA SQUIRELLA* DURING THE NON-BREEDING SEASON

EDIFICARIAN	(1 WEEK)												TOTAL
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	TOTAL				
CANS	2	2											4
RACK	4	9	8	18	31	24							94
OTHER		7	2	10	13	2				10			44
TOTAL EDIFICARIAN	6	18	10	28	44	26	0	10					142
NATURAL													
HOLLY	1	3											4
PALMETTO		1											1
TOTAL NATURAL													5
TOTAL	7	22	10	28	44	26	0	10					147

Sometimes it happens that a drop in temperature causes the frogs to return to their abodes well before daylight. This is to be expected since in this part of Florida the lowest temperature of the diel cycle usually occurs about 7:00 A.M. This means, of course, that it is possible for it to be warm enough for the frogs to move about early in the evening but to get too cold for activity long before morning. For example, on March 14, at 10:45 P.M., when the temperature was 57°, three frogs that had been out earlier were seen returning to their abodes. The temperature the following morning was 42°. On another occasion one was observed climbing the pole to a can at 9:50 P.M. when the temperature was 53°.

The frogs are still capable of activity when the temperature is in the low fifties or high forties although they do not ordinarily move at such temperatures. On the night of November 30, seven *squirella* which were out when the niches were examined at 8:30 P.M., temperature 52°, had returned by the next morning when the temperature was 53°. The overnight low was 48°. Again the next night, four frogs returned between temperatures of 48° and 51° with an overnight low of 40°. The lowest temperature at which any of the frogs were observed to be active was 44°. Two immature *squirella* were seen moving into can no. 1 at this temperature at 10:30 on the night of January 8.

Our observations suggest that the frogs may actively seek more sheltered niches, perhaps burrowing under the leaf mold or under rotten bark, with the approach of a cold front. On the morning of December 14, when the low temperature for the preceding 24 hours had been 55°, 13 *squirella* were recorded. That day the weather turned cold and windy, dropping to a low of 33° the next morning. Three of the *squirella* had left by 3:00 P.M.; when the niches were examined that evening, nine of the frogs had departed although the temperature was down to 49°. One more had left the following morning. High temperature for the 15th was only 52°, yet at some time during the day two of the remaining three frogs moved from the cans. These are temperatures at which *squirella* does not ordinarily move out to feed. The weather warmed up somewhat on the 16th, with a high temperature for the day of 59°. On the morning of the 17th, eight *squirella* had returned to their normal niches. That day it turned very cold again. High for the day was 50° and the low the next morning was 29°. By 3:00 P.M., two of the frogs had moved, and at 8:15, when the temperature had dropped to 40°, only one frog was found. That one was recorded as stirring; it had moved down to the bottom of can no. 5 from the top and was still there the following morning. If this apparent tendency of the frogs to move from their usual niches with the approach of a cold front is valid, then the bar diagrams in Fig. 1 would include this as well as feeding activity, and the overlap of the horizontal lines indicating range of temperature is greater than would be the case if only feeding activity were included.



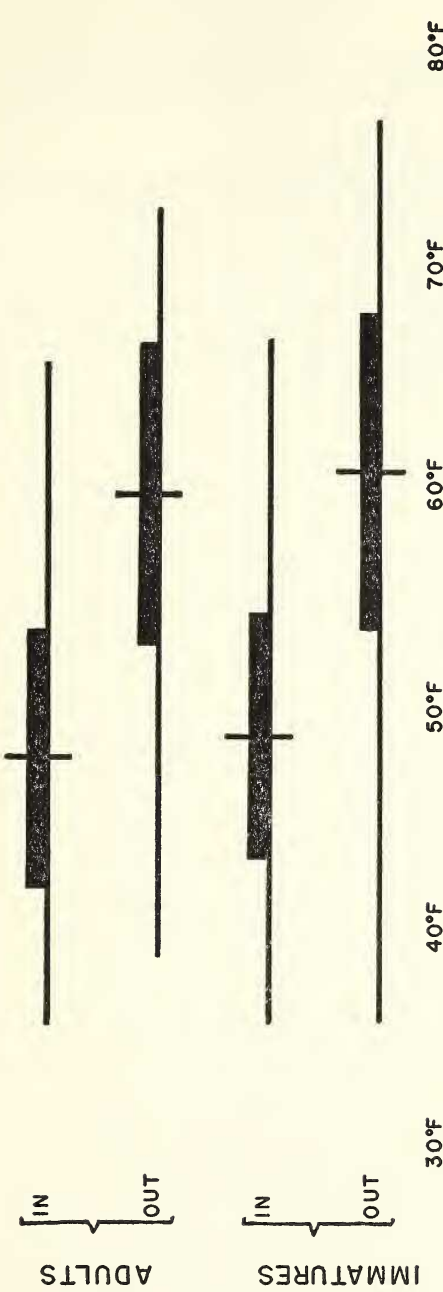


Fig. 1. Bar diagrams indicating the temperatures at which *Hyla squirella* adults and immatures are active at night (out) as compared with the temperatures at which they remain at rest (in)

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